

# Computational Methods to Minimize Bile-Duct Injuries in Laparoscopic Cholecystectomy

## Abstract

Cholecystectomy (gallbladder removal) is one of the most common procedures in the United States, with more than 1.2 million procedures performed annually. Compared with classical open cholecystectomy, laparoscopic cholecystectomy (LC) is associated with significantly shorter hospital stays and quicker convalescence periods, and hence is the preferred method in the majority of such surgeries (over 92%). However, LC is also associated with a 3-fold increase in the incidence of bile duct injuries (BDIs), resulting in significant morbidity and mortality. There are 5,000-10,000 incidences of BDI from LC annually in the US, leading to reduction in quality of life, numerous litigations and over a billion dollars per year in additional healthcare costs in the US alone. The primary causative factors of BDIs from LCs are: (i) misidentification of the cystic duct with the bile duct, and (ii) lack of understanding and/or loose adherence to the key safety protocol, viz., critical view of safety (CVS), which is widely regarded to be an effective method for target identification.

The goal of this project is to develop artificial-intelligence techniques to minimize the incidence of BDIs from LCs. Towards this we will employ a two-fold approach:

1. To ensure BDI-free LCs, we will develop decision-support methods that will raise alerts in real-time (i.e., while LC surgery is in progress) so as to prevent any duct or structure from being cut prior to attaining CVS. In addition, the methods will provide feedback that can be utilized to guide corrective actions.
2. To equip surgeons, particularly residents, with a better understanding of the CVS criteria and LC surgery in general, we will develop techniques for (offline) grading of LC surgical videos. For videos with low grades, the grade-driving factors will be identified and feedback will be provided based on instructive surgery-video segments appropriately chosen from a database of curated surgery videos.

An innovative aspect of our research is centered on developing specialized machine learning techniques for identifying CVS with very high accuracy, by incorporating domain knowledge to compensate for the limited training data available in practice. **Our long-term goal** is to develop a comprehensive solution that prevents incidence of BDIs in LCs, by incorporating strategies for handling rare anatomical cases, identifying bailout scenarios, and other strategies suggested by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) to minimize BDI risk. The proposed research has the potential to create new technologies that can prevent the incidence of BDIs from LCs and thus lead to better patient outcomes, and more generally, promote the development of similar technologies to address complications that can arise in other kinds of surgeries.